

Busek SmallSat Technologies

Planetary CubeSats Symposium

Aug 17th 2018

NASA Goddard Space Flight Center

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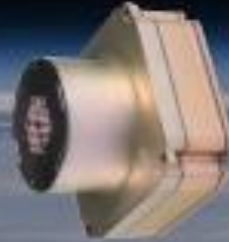
Space Propulsion
and Systems

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Cubesat & SmallSat Propulsion (6kg-220kg)



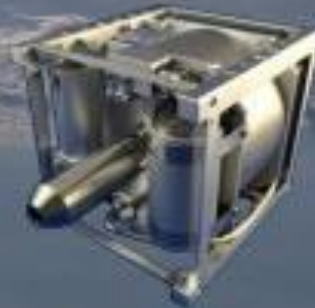
BET-300P



BmP-200



BIT-3



BGT-X5



BHT-200



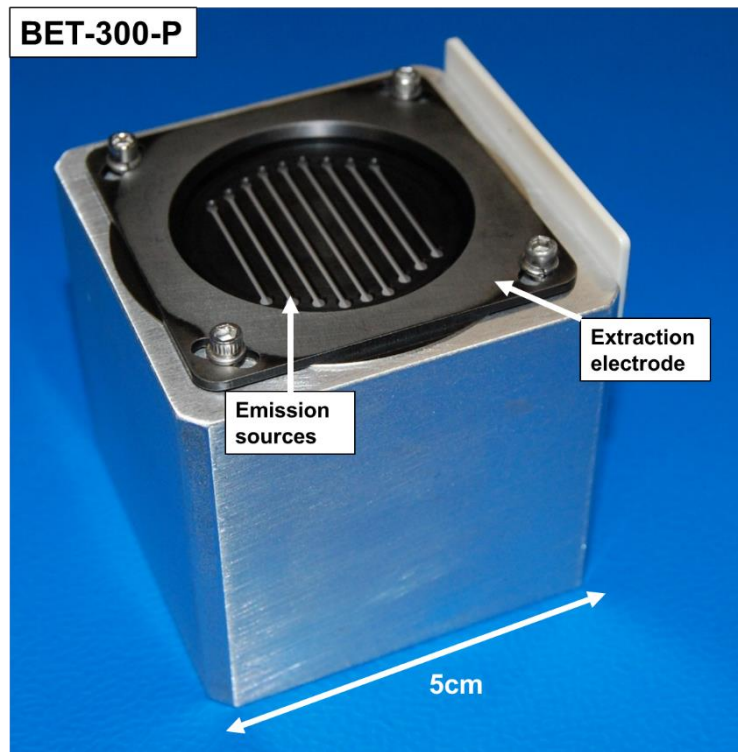
BHT-600

BET-300-P Electropray Thruster

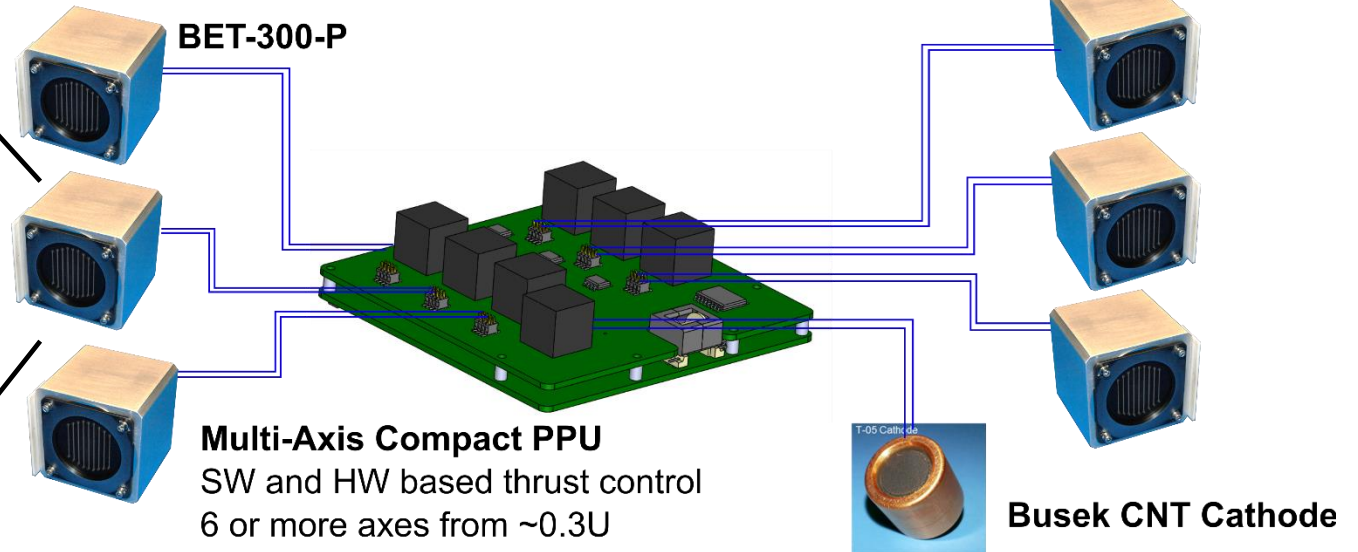
Busek CMNT on LISA Pathfinder : Successful Demonstration of Electropray Thrusters for Precision Control

↳ $<0.1\mu\text{N}$ resolution, $<0.1\mu\text{N}/\text{Hz}^{1/2}$ noise

↳ BET-300-P / RCS Seeks to Provide Precision Control Electropray Features to Small Spacecraft

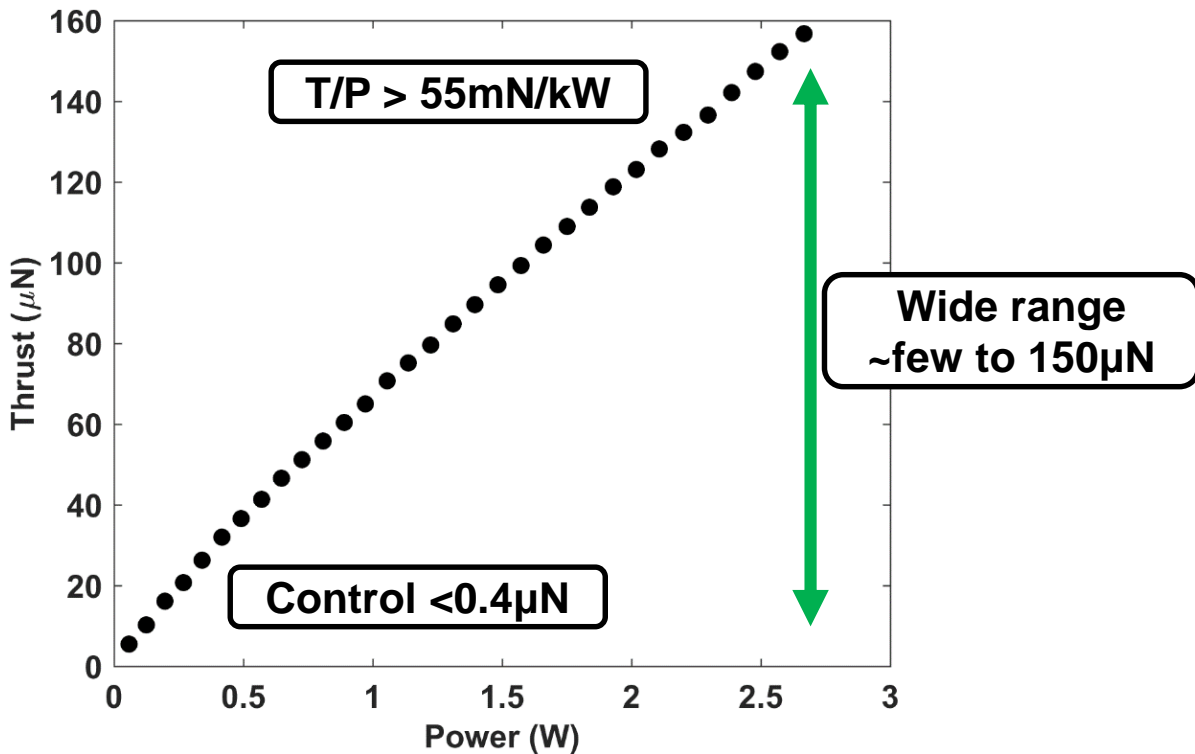


Busek Multi-Axis Modular Electropray RCS

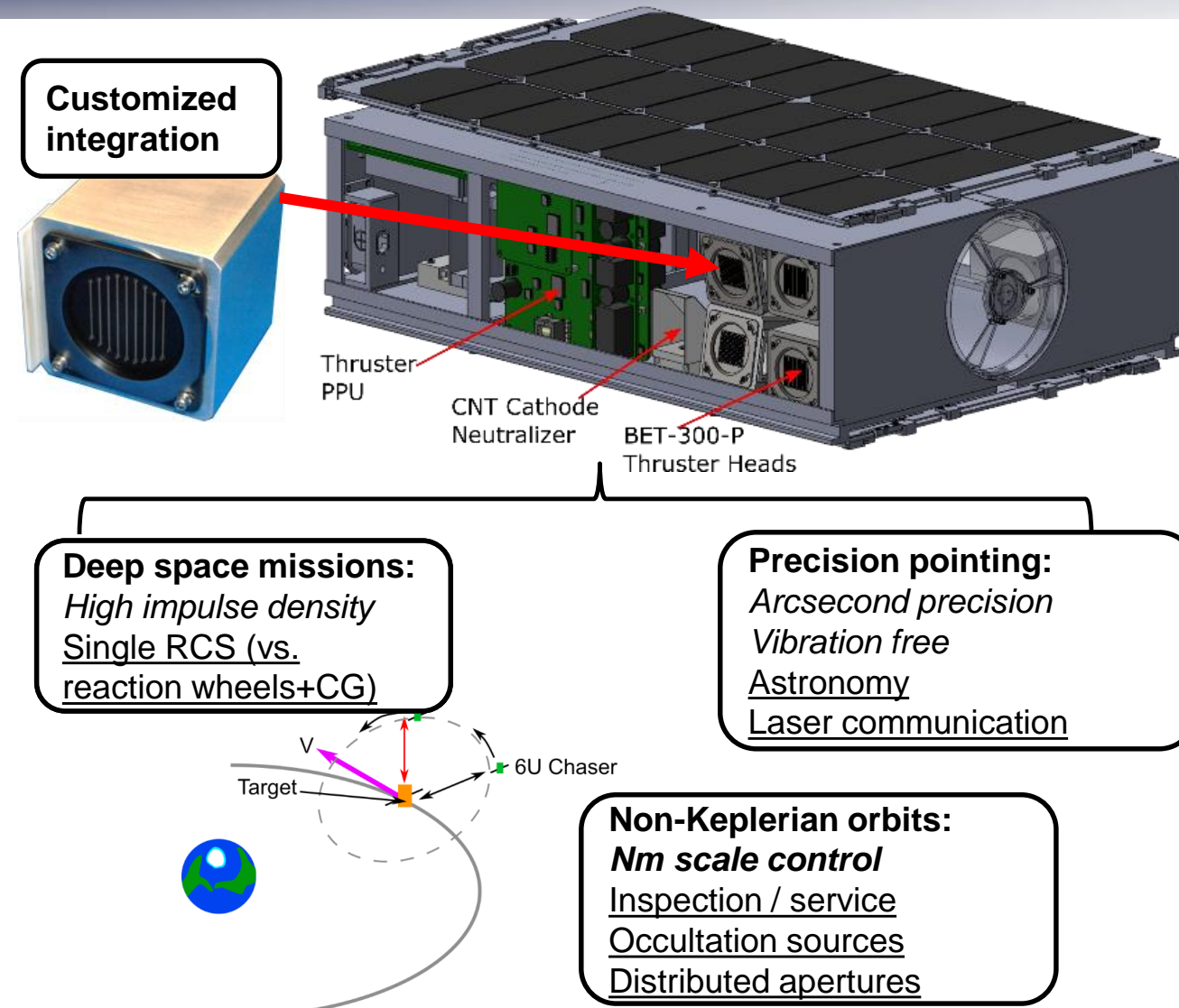


BET-300-P Performance and Applicable Missions

Performance: High T/P, Precision Actuator

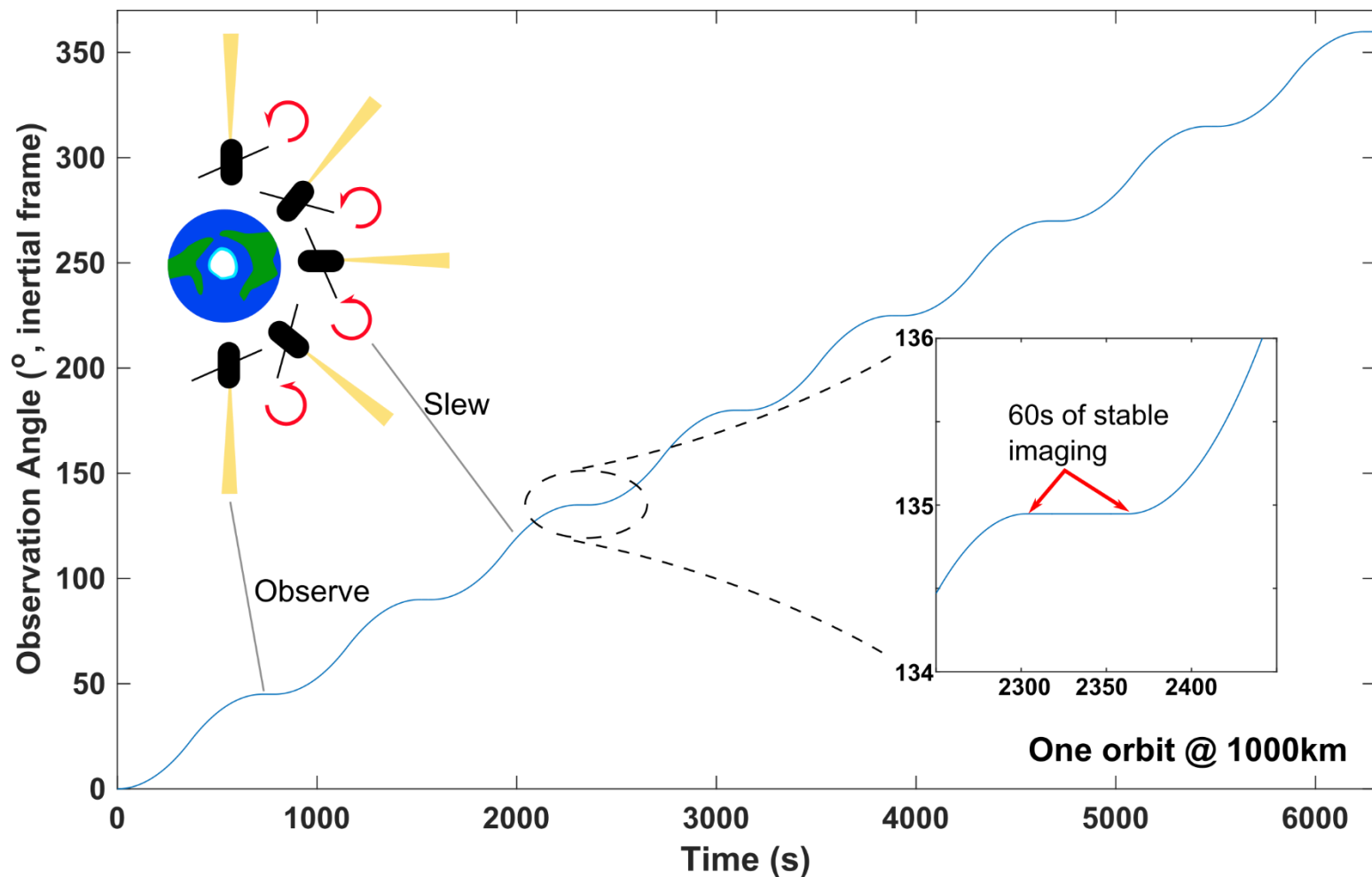


- Low noise (calculated) $< 0.1 \mu\text{N}/\text{Hz}^{1/2}$ [10mHz – 10Hz]
- High impulse density $\sim 1000 \text{Ns}/\text{U}$ (1000s Isp)
- Low impulse bits $\sim 2 \mu\text{Ns}$



BET-300-P Example Mission Scenario

6U CubeSat observatory tasked with taking long exposure inertial-stare images

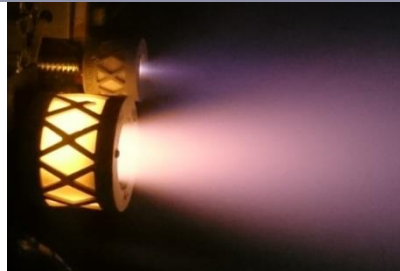
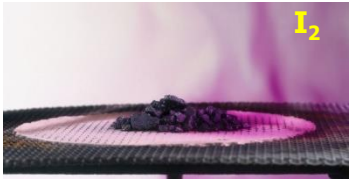


- Precision ACS via electrospray holds target centroid to sub-arcsec over 10's of seconds
- Same ACS used to slew to next image position

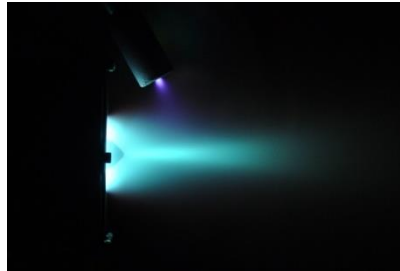
<i>Images</i>	100/day
<i>Impulse /image</i>	1.7mNs/img
<i>Impulse /year</i>	125Ns/yr
<i>Margin</i>	100%
<i>Total impulse</i>	250Ns/yr
<i>M_{prop} @ 65s Isp</i>	400g/yr
<i>M_{prop} @ 1000s Isp</i>	26g/yr

BIT-3 RF Ion Thruster

Iodine Propellant



BIT-3 RF Ion

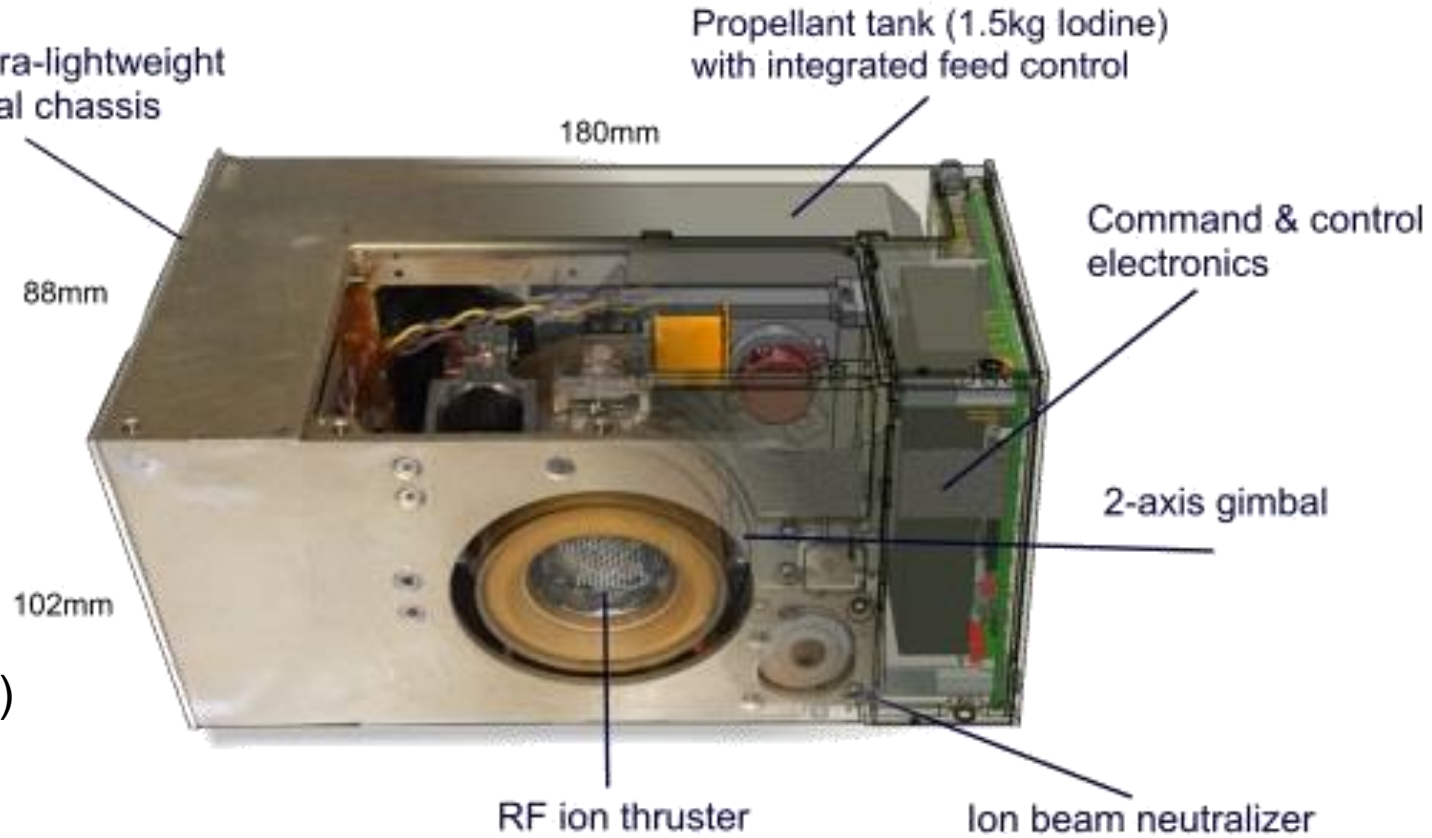


BHT-200 Hall Effect

BIT-3 Features

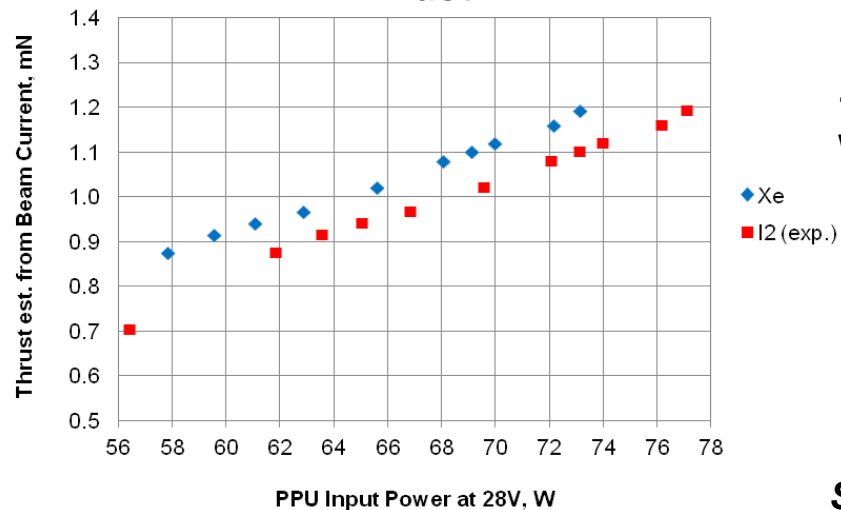
- Integrated, “plug-n-play” propulsion unit
- 1.6U volume, 2.9kg wet (1.5kg solid iodine prop)
- RF ion thruster and RF cathode
- 2-axis, $\pm 10^\circ$ thruster gimbal
- Propellant management system
 - Lightweight, heated iodine tank
 - NASA launch safety approved
- Mini Power Processing Unit (PPU) , Smallest ion engine PPU; SOTA power conversion efficiency (>83%)

1.6U ultra-lightweight structural chassis



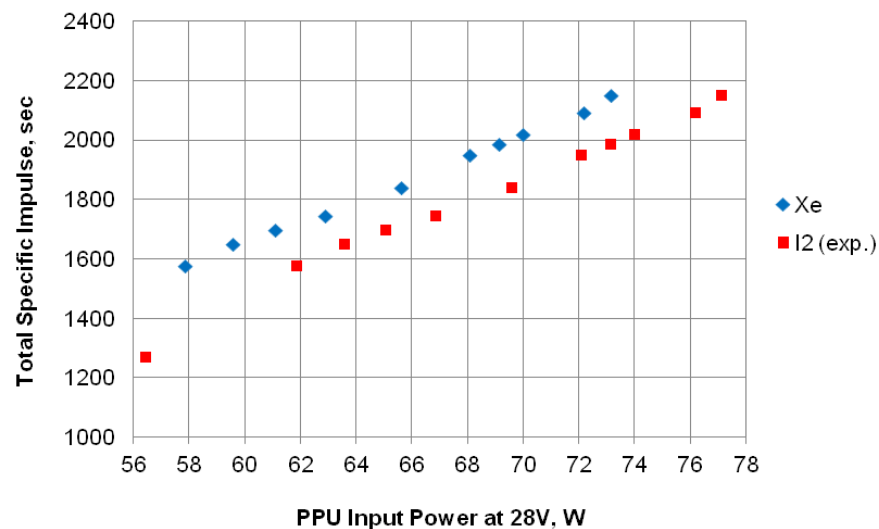
BIT-3 RF Ion Thruster Performance

Thrust



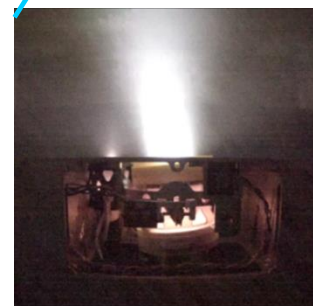
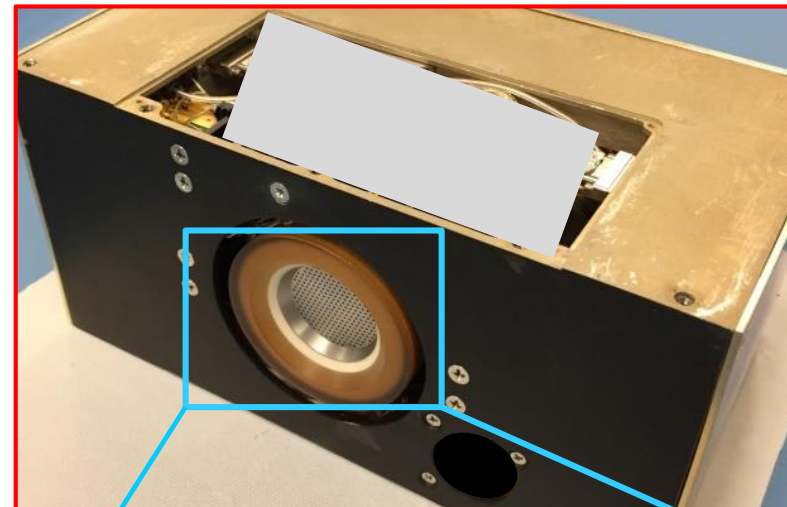
~0.7 to 1.2mN @ 55 to 80 W (system) power

Specific Impulse



1400-2160s I_{sp}
~31000Ns total impulse
(19kNs/U)

Gimbal Demonstration



+10°



0°



-10°

BIT-3 RF Ion Thruster : Status and Missions

BIT-3 Flight Hardware



Lunar IceCube (led by Morehead State University)

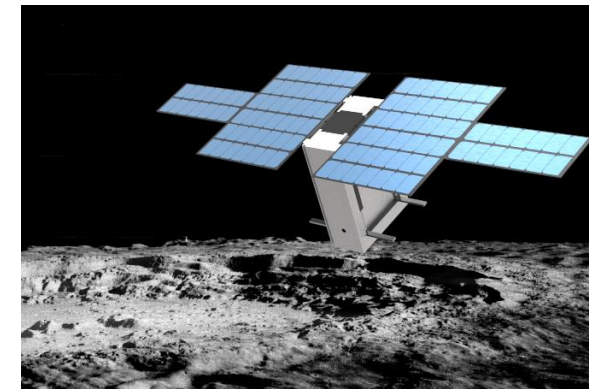
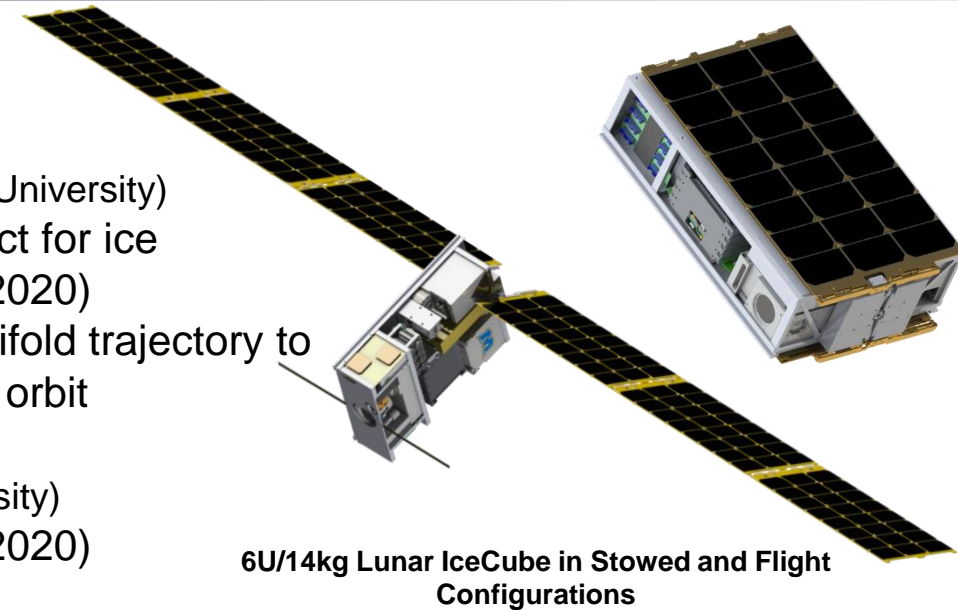
- 6U CubeSat lunar mission, prospect for ice
- Deploy by NASA's SLS on EM-1 (2020)
- BIT-3 applied with low energy manifold trajectory to achieve lunar capture and science orbit

LunaH-Map (led by Arizona State University)

- Deploy by NASA's SLS on EM-1 (2020)

BIT-3 *flight hardware undergoing final preparation for delivery; presently booking orders for 12 month delivery.*

4,000-hr life test, funded by NASA for risk reduction;
Test to begin in 2018



6U/14kg LunaH-Map in Flight Configuration

AMAC : 1U CubeSat Green Monopropellant System

AMAC Features

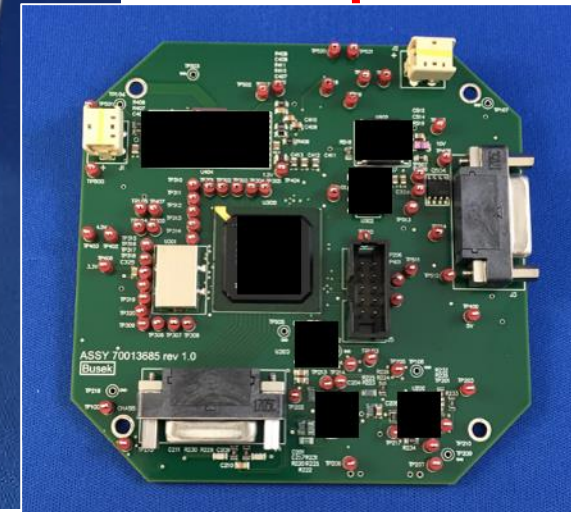
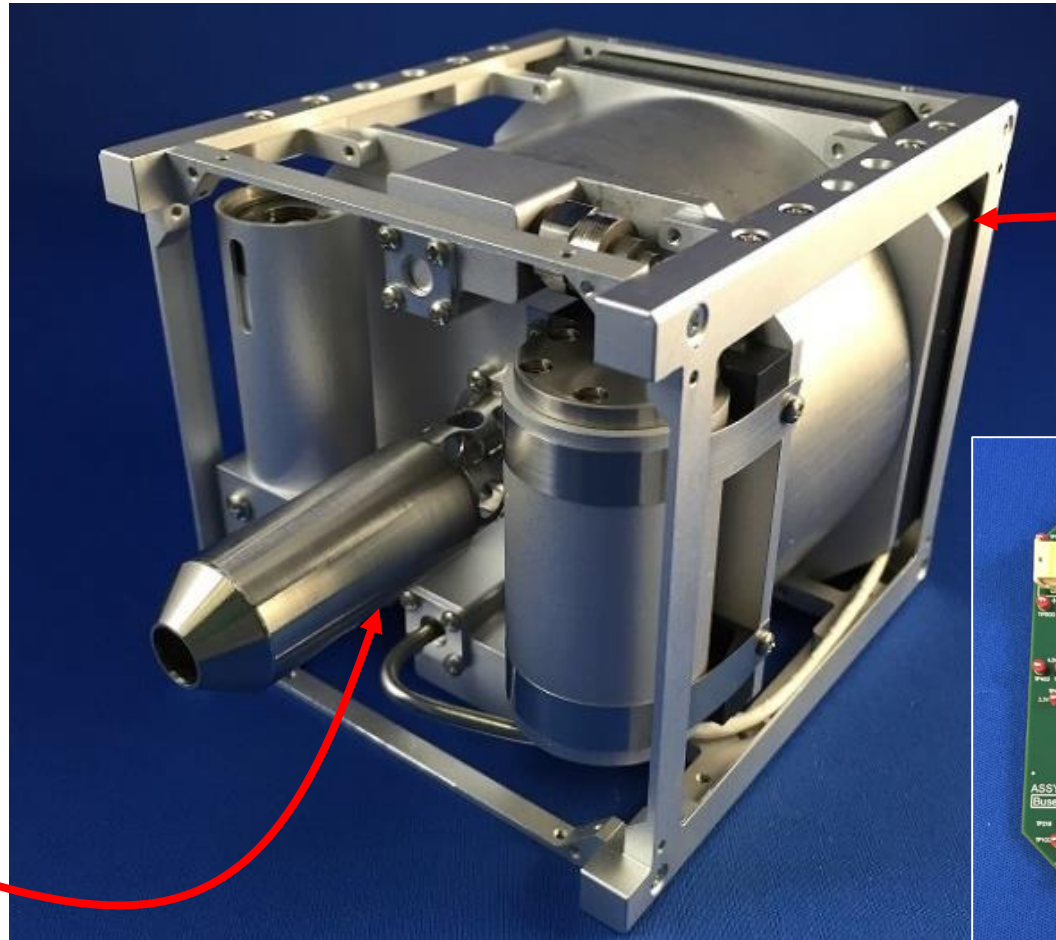
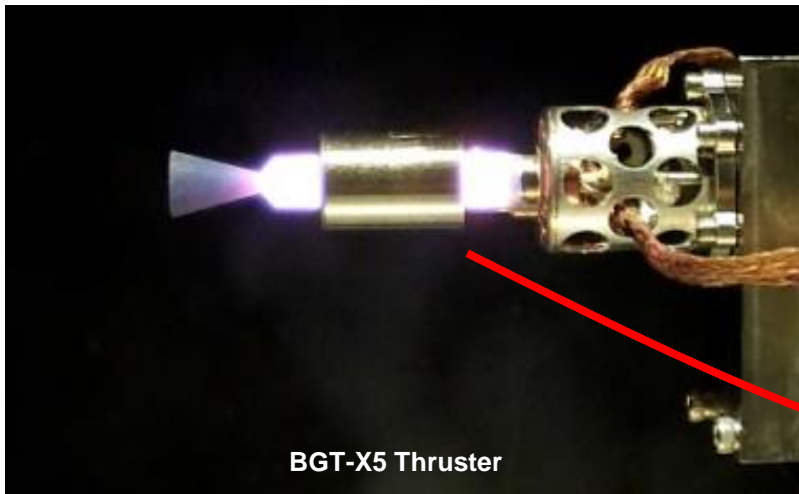
Integrated propulsion system (propellant, PPU, thruster)

- 1.5 kg (wet)
- 565 Ns total impulse
- Single 0.5N thruster (BGT-X5)

Post-launch pressurization system (PLPS)

Integrated electronics / digital interface

- Rad-tolerant power electronics
- 20W input power



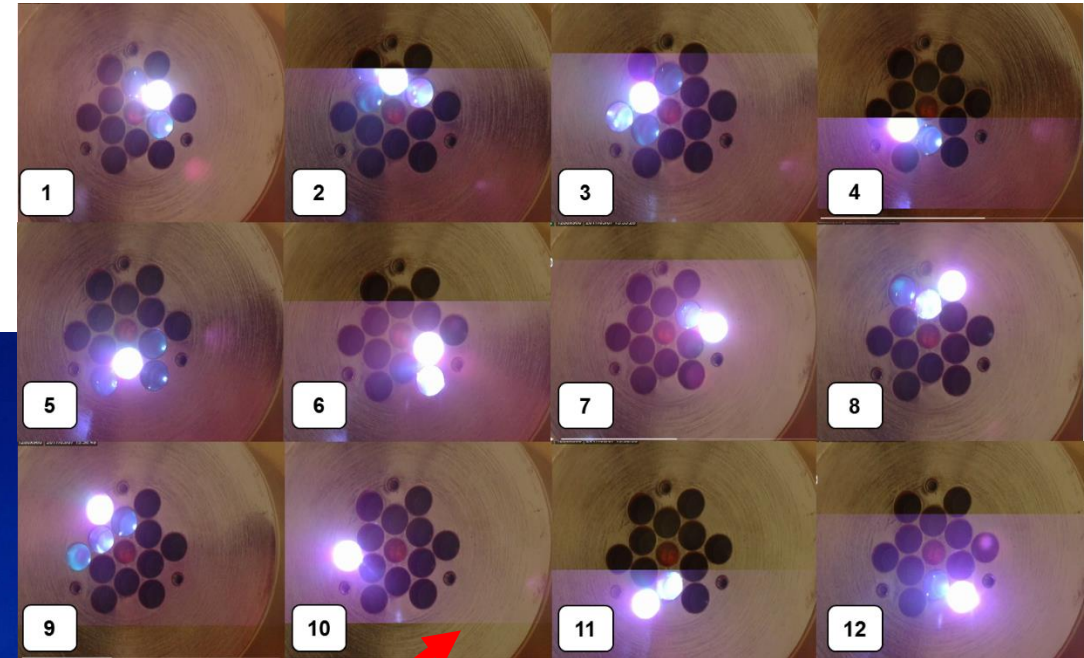
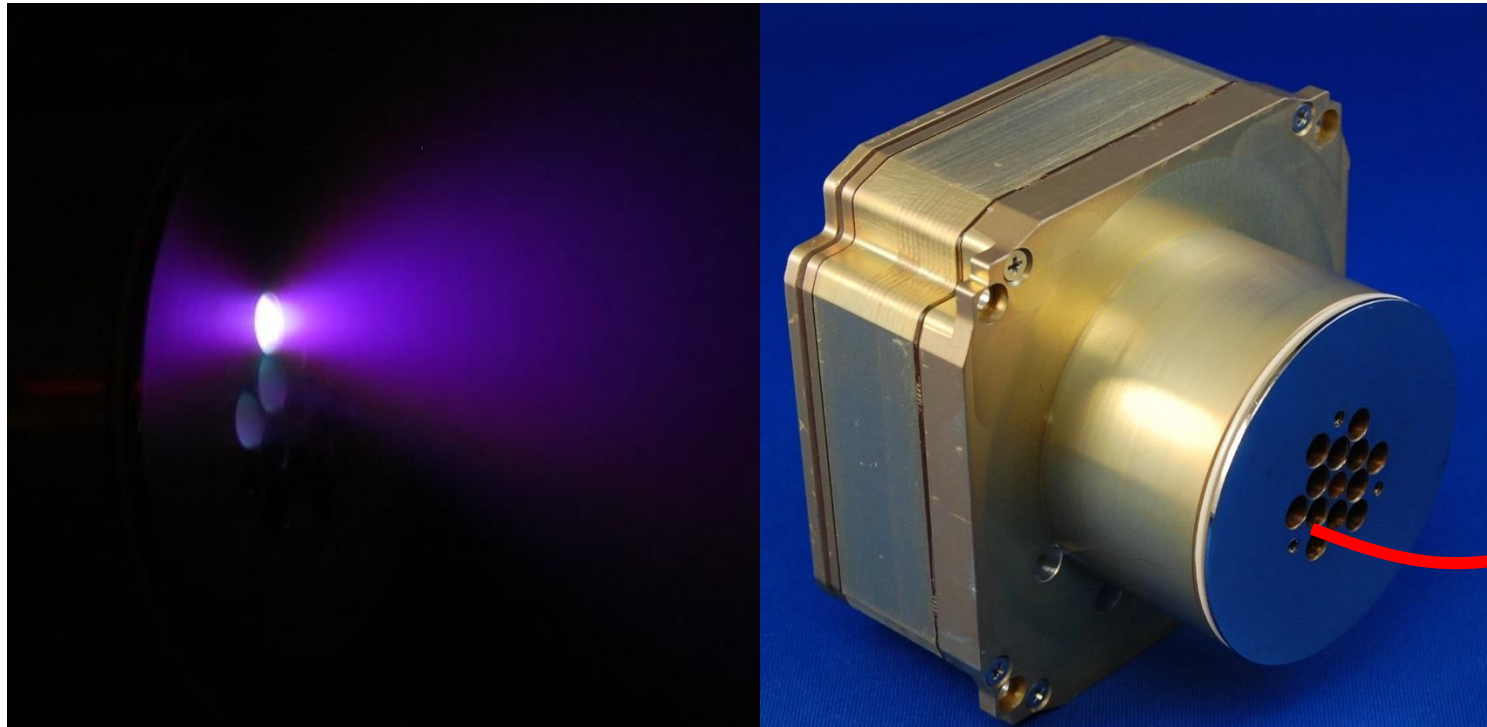
BMP-220 mPPT Thruster System

BMP-220 Features:

Co-axial PPTs, heritage from FalconSat 3 (2007)

Fully integrated system

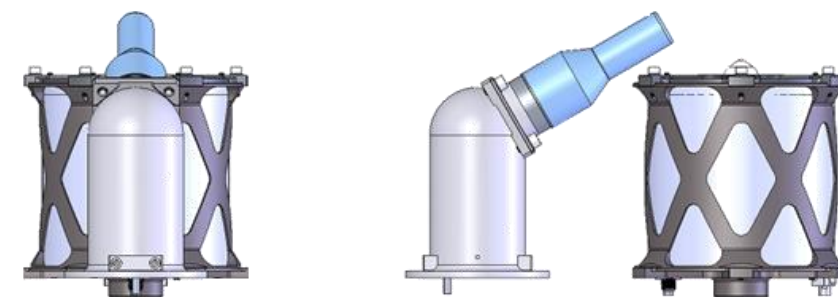
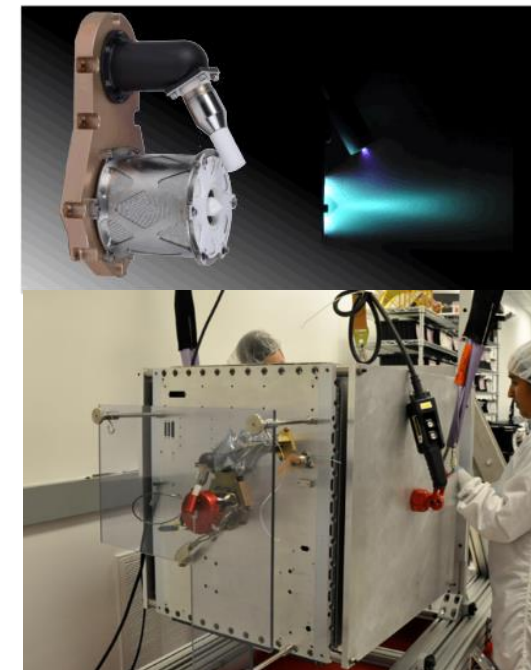
- <0.5U module + 'tuna-can'
- Avg. Ibit ~20 μ Ns, \leq 2Hz repetition rate
- 150-170Ns total impulse



12 selectable PPT 'sticks'

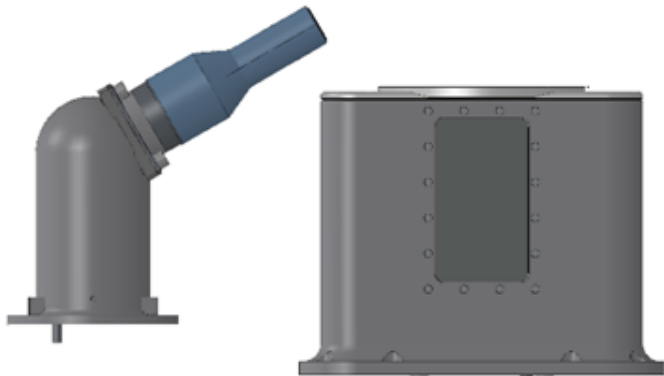
BHT-200 Hall Thruster System

- Flight-proven Xenon propulsion system; first US Hall thruster in space (2006)
- Multiple deliveries of complete integrated systems; thrusters, cathodes, PPU, feed systems tank, harness, brackets; system hot-fire acceptance tests.
- Iodine compatible anodes & valves
- Compact 100kRAD PPU in active development; legacy PPU being sunset
- 2,000 hours demonstrated life, voluntarily terminated



BHT-600 Hall Thruster System

- BHT-600 actively advancing to flight status
- Compact 100kRAD PPU
- Xenon and Hybrid iodine variants
 - 5,000 hr all-Xe thruster duration test at GRC underway
 - 1,200 hr hybrid Xe + I variant successfully tested 1,200 hours (10kg iodine), GRC



Thank You

Selected Customers:

